**374f Fault-Tolerant Control of Nonlinear Process Systems: Handling Sensor Malfunctions**

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Increasingly faced with the requirements of safety, reliability, and profitability, chemical process operations are necessarily relying on highly automated control systems involving a large number of sensors. As process devices, sensors are subject to failure, intermittent sensor data losses, biased measurements, etc., but as information sources sensor failures lead to erroneous control system actions, potentially causing a host of economic, environmental, and safety problems that can seriously degrade the operating efficiency of the process. If not detected and dealt with, sensor malfunctions that result in erroneous or inaccurate information to control systems can eventually lead to an increase in the wasteful use of raw material and energy resources, increase in production losses and possible downtime and ultimately causing physical damage and jeopardizing personnel and environmental safety.

The above considerations provide a strong motivation for the development of methods and strategies for the design of advanced control systems that manage sensor malfunctions and reduce the risk of safety hazards. In [1] we derived an integrated fault-detection and fault-tolerant control structure to handle actuator failures under the assumption of well functioning sensors. In this work, we consider the problem of implementing fault-tolerant control to nonlinear processes subject to sensor malfunctions. To this end, we first consider the state feedback problem and analyze the robustness of a Lyapunov-based predictive controller [2] with respect to sensor malfunctions as well as propose appropriate modifications in the control design that imbue the controller with the desired robustness properties. We will initially focus on sensor malfunctions manifested as intermittent data losses. Specifically, we cast the problem in a switched-systems framework, where in one mode the Lyapunov-based predictive controller receives the measurements and changes the value of the manipulated input, and in the second mode the controller does not receive the sensor information and computes the control action based on the last available measurement. A Lyapunov-based analysis is employed to compute the maximum allowable interval between two successive measurements. In process applications, all the state variables may not be available as measurements necessitating the design of nonlinear observers to estimate the states from the available measurements. We derive the necessary conditions on the observer gain and the maximum allowable interval between successive measurements given the process is required to go to a desired neighborhood of the origin. In this context, we also consider the problem of sensor failures and study the implications in loss of observability. Simulation studies are presented to demonstrate the implementation and evaluate the robustness of the Lyapunov-based predictive controller with respect to sensor malfunctions.

References:

[1] Mhaskar, P., A. Gani, N. H. El-Farra, P. D. Christofides and J. F. Davis, Integrated Fault Detection and Fault-Tolerant Control of Process Systems, Proceedings of 16th International Federation of Automatic Control World Congress, to appear, Prague, Czech Republic, 2005.

[2] Mhaskar, P., N. H. El-Farra and P. D. Christofides, Predictive Control of Switched Nonlinear Systems with Scheduled Mode Transitions, IEEE Trans. Autom. Contr., accepted as regular paper.